December 29, 2011

To: J. N. McKamy, Manager, US DOE NCSP

From: C. M. Hopper, Chair, US DOE NCSP CSSG CMH

Subject: **CSSG Tasking 2011-05, Report 1**

The CSSG has completed its action on Tasking 2011-05, *Independent Review of Godiva Safety*. As specified in the tasking, the review documentation is presented as two separate, stand-alone reports. This Report # 1 transmittal provides the report assessing Godiva operational safety.

The report was reviewed by the entire CSSG and comments were incorporated into the version that is attached. The attached version has the concurrence of the entire CSSG.

Cc: CSSG Members
A. N. Ellis
J. R. Felty
L. Scott
G.O. Udenta

Response to CSSG Tasking 2011-05, Report #1 of 2

Independent Review of Godiva Safety: Assessment of Operational Safety

Introduction

The Criticality Safety Support Group (CSSG) was directed in Tasking 2011-05 to provide a review of Godiva nuclear safety. As requested in the tasking statement (provided as Attachment 1), the response is provided as two separate, stand-alone reports. This report provides the assessment of Godiva operational safety.

Executive Summary

The review team concluded that planned Godiva operations incorporate operational safety provisions that are adequate for the startup and operation of the reactor. This conclusion is primarily based on a comparison of documented operating plans and procedures with guidance of national consensus standards [ANS-1-2000 (R2007)[1] and ANSI/ANS-14.1-2004 (R2009)[2]] and the experience and expertise of the review team members. The review and associated conclusions of this report exclude evaluation of safety basis documentation compliance to Department of Energy (DOE) regulatory requirements.

The review team offers two recommendations to improve the overall safety posture of Godiva operations. One recommendation is to examine operating procedures for simplifying changes that may reduce distractions to operations personnel or divert attention from the control panel. The second recommendation is to examine the function of the Criticality Experiments Safety Committee for possible expansion of membership qualifications, including consideration of an external member with fast pulse reactor experience, and for involving the Committee in resolution of issues having potential indirect impact on safety or efficiency of critical experiment operations.

Review Team Composition

Three CSSG members and eight ad hoc members were assigned to conduct the review and prepare this response for subsequent review and concurrence by the entire CSSG. The review team consisted of the following members:

[CSSG Members]
- Davis A. Reed (ORNL, writing team lead)
- James A. Morman (ANL)
- David P. Heinrichs (LLNL)

[Ad hoc Team Members]
- John T. Ford (SNL)
- Richard L. Coats (SNL)
- James R. Felty (SAIC)
- Bradley J. Embrey (NNSA CDNS)

Richard C. Crowe (NNSA CDNS)
Howard G. Goldin (NNSA NSO)
Jerry E. Hicks (NNSA)
Jeffry L. Roberson (NNSA)

The review team included individuals with experience and expertise in a wide range of DOE nuclear reactor and nuclear facility operations, or activities that support nuclear operations, including:

- work at pulse reactor, critical experiment, and test/production reactor facilities,
- work at highly enriched uranium and plutonium production facilities,
- work at nuclear research laboratories,
- generation, maintenance, or implementation of safety basis documentation, and
- performance of operational or regulatory oversight.

Topics of the Review

As directed by the tasking statement, the review team examined the following topics:

- Godiva System Design Description (SDD)
- Human Machine Interface (HMI)
- Safety channels and their associated Safety Integrity Level (SIL) analyses,
- Nuclear safety control set
- Operational procedures
- Godiva experiment planning and approval process
- Godiva start-up plans/schedule

Since this was a safety review, the Godiva SDD was not examined for conformance to DOE-STD-3024-98[3]. Instead, the SDD was reviewed from the standpoint of utility to the various intended users (experimenters, support engineers, maintenance personnel, etc.) and whether it adequately identified and explained appropriate safety-related systems.

HMI refers to the operational controls and displays used to perform remote or local operations of Godiva and to monitor the reactor status. The Godiva safety shutdown system (safety channels and "SCRAM" system) is physically and functionally independent of the HMI and serves a distinct and dedicated redundant safety function (to ensure the reactor is promptly brought to a shutdown condition in event of high radiation levels or upon operator directive).

"Nuclear safety control set" refers to those controls [design, operational (HMI) and safety channels] used to meet the guidance of the applicable American National Standards Institute/American Nuclear Society (ANSI/ANS) national consensus standards. The scope of this review is limited to operational safety, and did not assess compliance to DOE regulations related to incorporation of control set elements in safety basis documentation.

Conduct of the Review

Three teleconferences (October 21, November 17, and November 22, 2011) were held. The initial teleconference, involving the DOE Nuclear Criticality Safety Program (NCSP) Manager and support staff, the CSSG Chair and several CSSG members, and select Los Alamos National Laboratory/National Critical Experiments Research Center (LANL/NCERC) staff/management, focused on review team selection, scope, and schedule. Following the first teleconference, the CSSG tasking statement was finalized and approved (October 25). Subsequently, the second and third teleconferences primarily involved the review team (identified in the approved tasking), key LANL staff supporting performance of the review, and DOE NCSP management.

The team performed an on-site visit to the Device Assembly Facility (DAF)/NCERC on November 30, followed by two days of meetings at the Nevada Site Office (NSO).

The November 30 on-site visit provided the team with overviews of the Godiva machine, support equipment in/near the experimental room, and the control room facility. The visit provided opportunities for the review team to interact with LANL staff assigned for performance and management of Godiva operations, and to observe a complete "dry run" execution of the procedure for a Godiva pulse operation.

The December 1 meetings at the NSO involved extensive review and discussion of the review topics with LANL/NCERC staff and NSTec (National Security Technologies, LLC) safety basis management. The December 2 meetings involved assimilation of learned information and viewpoints of the review team members, with formulation of consensus opinions regarding review conclusions.

Review Observations by Topic Area

A. Godiva System Design Description (SDD)

Three SDDs[4,5,6] provide thorough descriptions of all Godiva system components and their associated functions. The SDDs identify how the system design and/or means of operator use meet various safety guidance of the applicable national consensus standards[1,2]. This identification (sometimes referred to as a "crosswalk") is viewed as a noteworthy practice.

The SDDs also identify other applicable standards or source requirements, such as LANL institutional requirements for engineering design and requirements resulting from the DAF/NCERC Documented Safety Analysis[7] (DSA). The SDDs provide listings of specific design documentation (e.g., engineering drawings and specifications for individual components and subsystems).

The Godiva SDDs are informative documents of considerable utility to NCERC staff and support staff. The SDDs foster configuration management of the Godiva reactor and related systems. While the team did not compare the SDDs to physical systems, the

documentation appears to adequately cover all areas of the systems related to safe operation of the reactor.

B. Godiva Human Machine Interface (HMI)

The primary HMI is in the Godiva control room, with a more limited HMI deployed just outside the experiment room to support local operations such as maintenance, surveillances or setup. The HMI is controlled by a dedicated PLC (Programmable Logic Controller) that is completely separate from the safety shutdown system PLC.

The control functions and displayed information of the HMI units are appropriate. Extraneous information is not displayed; non-essential functions (i.e., HMI functions other than those necessary to support Godiva operations, maintenance, or surveillance objectives) are not present. Display controls are operator friendly and of modern design. Adequate design features are incorporated to prevent simultaneous local and remote operation, and to require two-person actions for critical operation steps.

The HMI does include limited, but directly relevant non-HMI functions, such as provision of safety channel status and control for direct operator shutdown (SCRAM). However, it is emphasized that the safety channels and HMI systems remain independent.

C. Safety Channels and Their Associated Safety Integrity Level Analyses (SILs)

The engineered controls consist of startup and audible neutron counters, manual SCRAM buttons, door interlocks, and Log-N channels. Only the door interlocks and redundant Log-N channels are part of the automatic safety shutdown system.

Based on ANSI/ISA 84.01[8], SILs have been determined for these engineering controls and are documented in CEF-ENG-CAL-0419, Revision 3[9].

D. Nuclear Safety Control Set

The review of controls focused on consistency with safety guidance of ANS-1-2000 and ANS-14.1-2004. This is distinct from a review of compliance with DOE regulatory requirements or guides regarding how such controls should be classified (e.g., "safety significant," "specific administrative control") or utilized within regulatory documents such as DSAs or Technical Safety Requirements (TSRs).

The controls for operation of Godiva, as outlined in operating procedures and documents such as the SDDs, are consistent with the referenced industry-consensus standards and provide an adequate control set for operation of the reactor.

E. Operational Procedures

The primary operating procedure[10] for Godiva was reviewed by the team and demonstrated in real time by NCERC staff during a simulated burst operation.

During the ~ 3 hr "dry run," activities were performed or simulated in accordance with the procedure. The procedure is comprehensive for the activity (i.e., multiple procedures were not necessary to perform the work). The Crew Chief and Crew Member had no difficulties in applying the procedure, which is an "in-hand use" procedure, incorporating two-person signoff as key steps are performed.

The review team identified two potential opportunities for improvement in operating procedures, discussed below and restated in the Conclusions section of this report.

It is imperative that in the sequence just prior to performing a pulse operation, that distractions to the operators be minimized. This sequence includes determination of delayed critical conditions, establishment of the amount of excess reactivity above prompt critical, monitoring of conditions during the wait period, and performance of the pulse. It is during this time that the highest probability for an operator error of consequence exists. To the extent practical, distractions and non-essential administrative actions should be limited during this time. [DOE guidance re control area (control room) activities may be found in DOE O 422.1 Attachment 2, Section 2.c plus Appendix A, and DOE-STD-1042-93 CN-1.]

A potential distraction is the presence of non-essential personnel in the control room. Here, non-essential personnel are considered to be staff or visitors who are not present for training purposes or do not have a defined role in performing or supervising experiment operations.

Another potential distraction is notification requirements, such as informing the DAF Facility Supervisor of operational status. To the extent practical, notifications should be performed outside periods of key decision-making by operators.

Throughout preparation and conduct of a pulse operation, unnecessary pressures on operators should be avoided. One potential pressure of note is the requirement that once the experiment room fire sprinkler system is deactivated, operators must formally transition to a burst-mode status within 2 hours. If unexpected interruptions occur during this period, operators may feel pressure to transition to the burst mode status so that loss of a day of productivity is avoided. This specific time limit appears arbitrary and should either be eliminated from the operating procedure or significantly lengthened (for example, to 8 hours). (This change will also require revision to the NCERC Technical Safety Requirements document.)

In summary, the review team recommends that the operating procedure be reviewed for possible

- reductions in operator distractions during key periods of operator decision-making (e.g., presence of non-essential personnel in the control room, timing of notifications), and for
- reduction in unnecessary pressures on operators (e.g., transition to burst-mode status based on time limits).

F. Godiva Experimental Planning and Approval Process

The team reviewed several documents[11-15] related to experiment, planning, review, and approval of Godiva operations.

These documents and described activities are considered adequate for performance of Godiva operations, but the review team felt that opportunities may exist for improvement in utilization of the Criticality Experiments Safety Committee.

The review team recommends the following:

- that the committee membership includes personnel with expertise in fast pulse reactor operations, preferably external to LANL and NSTec,
- that the committee membership includes permanent external (to NSTec and LANL) members, and
- that the committee be involved in resolution of issues beyond experiment planning/performance and periodic operational reviews.

G. Godiva Start-up Plans/Schedules

During the review, the next formal milestone for Godiva was identified as assembly of Godiva components, to occur in January 2012. While operational safety of this activity is out-of-scope for this review, the feasibility of meeting this schedule was considered by the review team.

The NSTec Safety Basis Manager indicated that some criticality controls in the nuclear criticality safety evaluation[17] for the assembly activity need to be documented within the DSA[7]. The level of effort required for revision of the DSA to cover assembly operations is not clear to the review team, but it is apparent that limited calendar time is available to initiate, approve, and implement DSA changes. It is recommended that NSTec and NCERC work with NSO staff to expedite a DSA revision in order to minimize the schedule impact.

If there is delay in the assembly schedule, the schedule for subsequent Godiva startup activities (e.g., Godiva characterization) may be impacted. Also, certain regulatory issues identified in the Report 2 report of this CSSG Tasking 2011-05 response (related to Change Notice 3 to DOE-STD-3009-94[16]) may impact the schedule for Godiva assembly and/or subsequent startup activities.

H. Training for Godiva Operations Staff

Training of Godiva staff (Crew Members, Crew Chief) is not a review topic identified in the CSSG 2011-05 tasking statement. However, the review team concluded that subjective, but positive, indicators were observed during the dry run of November 30, and that these indicators should be mentioned within this report.

The two operations staff members were clearly aware of their responsibilities and familiar with the operating procedure, and conducted their duties in a professional, disciplined manner. While these attributes may be due to multiple causes, the observations support the conclusion that the Godiva operations staff members who performed the dry run are trained and capable.

Conclusions

The review team concluded that the Godiva reactor can be safely operated within the framework of documentation that currently exists. The compliance of the documentation with current DOE regulations, standards and guides was not evaluated and is not included in this review team conclusion. Each of the seven Topics of Review was considered and concluded to be adequately covered by the associated documentation or hardware systems.

The review team offers three recommendations for improvement of the operational safety of the Godiva facility.

1) The Operating Procedure for the Godiva Critical Assembly should be examined for possible reductions in operator distractions during key periods of operator decision-making (e.g., presence of non-essential personnel in the control room, timing of notifications),

2) The Operating Procedure for the Godiva Critical Assembly should be examined for possible reduction in unnecessary pressures on operators (e.g., transition to burst-mode status based on a time limit related to deactivation of the fire sprinkler system).

3) Evaluate the membership and functions of the Criticality Experiments Review Committee to:
   (a) ensure that the committee membership includes personnel with expertise in fast pulse reactor operations, preferably external to LANL and NSTec;
   (b) ensure that the committee membership includes permanent external (to NSTec and LANL) members; and
   (c) involve the committee in resolution of and input to issues beyond experiment planning/performance and operational reviews.

A fourth (non-safety) recommendation is offered regarding the Godiva startup schedule.

4) NSTec and NCERC staff should work with NSO staff to expedite the DSA revision to address Godiva assembly operations.

References

1. ANSI/ANS-1-2000 (R2007), *Conduct of Critical Experiments*.
2. ANSI/ANS-14.1-2004 (R2009), *Operation of Fast Pulse Reactors*.
3. DOE-STD-3024-98, *Content of System Design Descriptions*.
4. CEF-ENG-SDD-0348 Rev. 5, *Godiva Critical Assembly System Design Description*.
5. CEF-ENG-SDD-0350 Rev. 5, *CEF Nuclear Instrumentation System Design Description*.
6. CEF-ENG-SDD-0351 Rev. 4, *System Design Description for the CEF SCRAM and Operational Interlock System*.
7. LLNL-MI-407120, *Device Assembly Facility Documented Safety Analysis Addendum for Criticality Experiments Facility Operations (DSA)*, April 2009.
8. ANSI/ISA-84.01-1996, *Functional Safety: Safety Instrumented Systems for the Process Industry Sector*.
9. Calc. No: CEF-ENG-CAL-0419, R3, *Layer of Protection Analysis for SIL Determination of the SCRAM System*.
10. CEF-SOP-003, R7, *Operating Procedure for the Godiva Critical Assembly*.
11. CEF-ADM-001, R2, *Experiment Plan Preparation Procedure*.
12. CEF-EXP-003, R5, *Experiment Plan for Godiva*.
13. CEF-EXP-005, R0, *Experiment Plan for Godiva Characterization*.
14. CEF-PLA-017, R0, *Godiva Pulse Energy Test Plan*.
15. *Charter for the Criticality Experiments Safety Committee*, February 8, 2011.
16. DOE-STD-3009-94, Change Notice 3, March 2006, *Preparation Guide for U. S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*.
17. NCS-CSED-11-002, *Criticality Safety Evaluation for Godiva-IV Assembly and Disassembly Operations at the DAF*, May 6, 2010.

Attachment 1

CSSG Tasking 2011-05

CSSG Tasking 2011-05
Date Issued: 25 October 2011

Task Title: ***Independent Review of Godiva Safety***

Task Statement:

The CSSG is directed to oversee and participate in an Independent Review of Godiva Safety prior to its reassembly and start-up at the Nevada National Security Site Device Assembly Facility (DAF) National Criticality Experiments Research Center (NCERC) and issue a US DOE NCSP CSSG Tasking 2011-05 Response.

Resources:

The review will be conducted by a Review Team that is comprised of selected CSSG members who are supplemented by ad hoc members with expertise in fast pulse reactor safety and safety basis documentation. The Review Team is to draft and provide a final tasking Response to the CSSG Deputy Chair. The CSSG Deputy Chair will distribute the Response to the full CSSG membership for review and comment. The CSSG Deputy Chair will address the CSSG member comments and forward the resulting revised Response to the CSSG Chair for transmittal to the NCSP Manager. Contractor CSSG members will use their FY12 NCSP CSSG support funding as appropriate; DOE CSSG members will utilize support from their site offices. CSSG emeritus members may be included on the team on a voluntary basis. The NCSP Manager will assure that support is available for ad hoc members.

Task Deliverables:

1. CSSG Review Team receives advance materials by October 21, 2011, for examination prior to the site visit.
2. CSSG Review Team meets for the work period 30 November through 2 December. A DAF NCERC site visit will be conducted to observe the planned operating environment of Godiva and its control systems. The balance of the work period may be conducted at the Nevada Site Facility or the DAF NCERC as appropriate.
3. CSSG Review Team develops a draft "US DOE NCSP CSSG Tasking 2011-05 Response" by December 9, 2011 that addresses the CSSG Tasking 2011-05 General Review Topics/Guidance/Information (see CSSG Tasking 2011-05 Attachment).
4. CSSG provides comments on the draft Response by December 14, 2011.
5. CSSG Chair briefs the NCSP Manager on the Response by December 16, 2011.
6. CSSG Chair transmits the final Response to the NCSP Manager by December 29, 2011.

Task due date: December 29, 2011

Signed: JN McKamy 10/25/2011
Jerry N. McKamy, Manager US DOE NCSP

CSSG Tasking 2011-05 Attachment

CSSG Tasking 2011-05 General Review Topics/Guidance/Information

1. **Godiva Operational Safety, i.e.,**
   a. Godiva System Design Description
   b. Human Machine Interface
   c. Safety Channels and their associated Safety Integrity Level analyses
   d. Nuclear Safety Control Set
   e. Operational Procedures
   f. Godiva Experimental Planning and Approval Process
   g. Godiva Start-up Plans/Schedule
2. **Stand-alone review responses regarding**
   a. The DNFSB issues relating Godiva as stated in their letter dated August 5, 2010 (see "DNFSB Letter on CEF Start-Up August 5, 2010 and its attached June 22, 2010 "Staff Issue Report") regarding
      i. *Inadequate Accident Analysis* of
         1. "Unmitigated Dose Analysis for Godiva"
         2. "Effects of Fuel Cracking"
      ii. *Inadequate Control Set* of
         1. "Design of Safety Instrumented Systems"
      iii. *Improper Characterization of Safety-Related Controls*
   b. The "LANL technical analysis/basis for compliance with 3009 CN3 for some SACs as an alternate accident analysis methodology at the DAF NCERC per established protocols for approving alternate methodology(ies) for implementing DOE-STD-3009 requirements of 10 CFR 830."

CSSG Tasking 2011-05 Subgroup Review Team and ad hoc Members

Selected CSSG Review Team members include:

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Point of Contact for DAF NCERC Site Access Arrangements

- Robert Margevicius (LANL)
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Point of Contact for Nevada Site Facility Meeting Room Space Arrangements

- Dirk Schmidhofer
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Distribution of Work Assignments/Responsibilities:

Under the CSSG leadership and coordination of Davis A. Reed, David P. Heinrichs, James A. Morman and Davis A. Reed are to participate, contribute, monitor and produce the US DOE NCSP CSSG Tasking 2011-05 Response as assisted by the expertise of Review Team ad hoc members as follows:

1. John T. Ford, Richard L. Coats, and James R. Felty are to focus on reviewing and reporting on the adequacy of Godiva operational safety, e.g.,
   a. Godiva System Design Description

b. Human Machine Interface
c. Safety Channels and their associated Safety Integrity Level analyses
d. Nuclear Safety Control Set
e. Operational Procedures
f. Godiva Experimental Planning and Approval Process
g. Godiva Start-up Plans/Schedule

2. Bradley J. Embrey, Richard C. Crowe, Howard G. Goldin, Jerry E. Hicks and Jeffry L. Roberson are to focus on reviewing and reporting on
    a. DNFSB issues relating Godiva as stated in their letter dated August 5, 2010 (see embedded "DNFSB Letter on CEF Start-Up August 5, 2010 and its attached June 22, 2010 "Staff Issue Report") regarding
        i. *Inadequate Accident Analysis* of
            1. "Unmitigated Dose Analysis for Godiva"
            2. "Effects of Fuel Cracking"
        ii. *Inadequate Control Set* of
            1. "Design of Safety Instrumented Systems"
        iii. *Improper Characterization of Safety-Related Controls*
    b. The "LANL technical analysis/basis for compliance with 3009 CN3 for some SACs as an alternate accident analysis methodology at the DAF NCERC per established protocols for approving alternate methodology(ies) for implementing DOE-STD-3009 requirements of 10 CFR 830."
3. Robert W. Margevicius is to facilitate Review Team access to the DAF NCERC.
4. Dirk Schmidhofer can assist in arranging Review Team meeting and work area.
5. All members of the Review Team (i.e., selected CSSG and ad hoc members) and the full CSSG membership are to examine the Tasking Responses. A "Difference of Professional Opinion" section shall be provided in each of the focused responses to address Review Team or CSSG member lack of concurrence with the consensus Tasking Response.